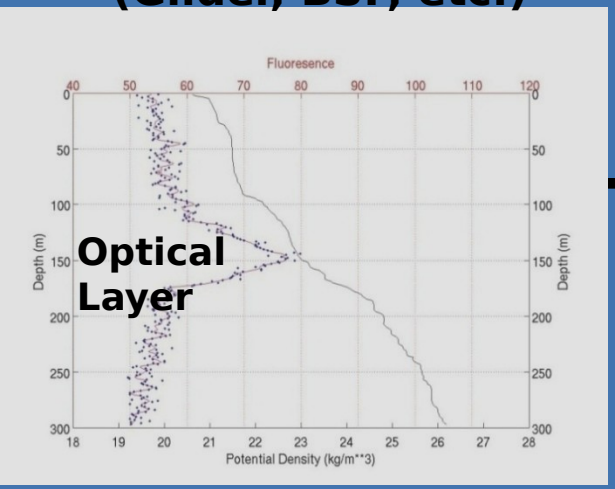
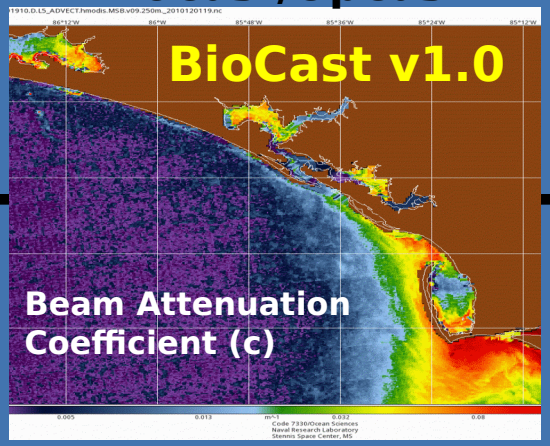
TODS Overview: Fusion of Glider Profiles, Satellite and Numerical Models to support AQS24 Operations

"Defining the optical environment for Navy Systems"

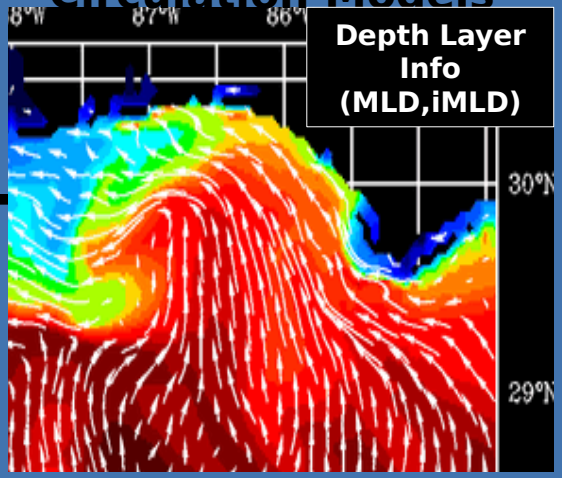
Vertical Optical Profiles (Glider, BSP, etc.)



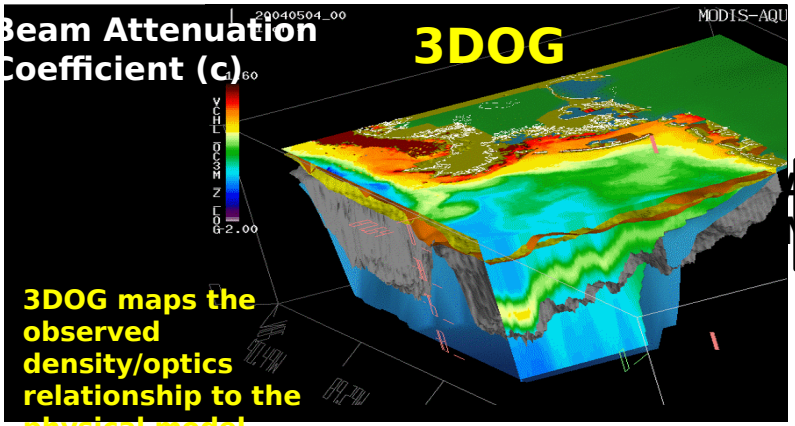
Nowcast / Forecast Satellite Optics BioCast/OpCast



Nowcast / Forecast Circulation Models



Optical Volume/Profiles & 3D Diver Visibility



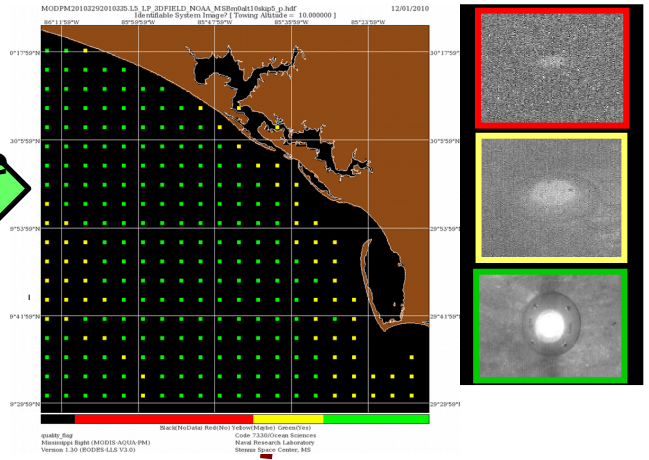
Insitu Physics/Optics Used to Tune Coeffs in 3DOG

AQS24 Performance Model (EODES)

Beam Attenuation Coefficient (c)

Nowcast/Forecast Performance Surface

Image Quality & Optimal System Towing Altitu



Overview of TODS Components

1) Display 2) OPCAST 2D / BioCast 3D
3) 3D and Performance Surfaces

NAVO Operational Inputs

Satellite Data Processing (AOPS)
NP3

RELO NCOM MODELS
lowcast / Forecas
NP3

LAGER
Glider Physics & Optics
Auto & Manual QC Software (FY11)
NP3 GOC

OpCast 2D (FY11)
ioCast 3D (FY13/15)
Advection Software

Optimization
Physical-Optical Coupling

Utilities
Post processing
Conversions optics
Interpolation

3D Optics Generator (3DOG) FY14

Performance Surfaces
- Diver Visibility/
- Vulnerability
- AQS-24 ALMDS

FY14

Real-Time Visualization/Display of Nowcast/Forecast Products

- **Fusion of Satellite and Model – provides real-time visual display interface for time series animations (pan + zoom)**
  - **MODIS, SEAWiFS, MERIS, OCM, NPP, AVHRR satellite imagery**
    (diver vis, beam attenuation (c), laser

Modeling, Sensing and Forecasting Ocean Optical Products for Navy Systems- TODS

FY13-14 Major Objectives & Milestones

MS Event/Action/Improvement Objective	Completion and/or Delivery Quarter/FY	Description of Capability Completed and/or Delivered
Optical Forecast – BioCast v1.0	**Delivered w/ VTR 1QFY14 OPTEST to start soon**	**Provides forecasts of surface coastal optical properties for water clarity, diver visibility (visual detection/vulnerability) and lidar penetration depth**
Bathygen v1.0	**Development Completed and delivered 1QFY14**	**Software developed to consistently generate bathymetry from supplied DBDB2 and GEBCO databases to match satellite grid from AOPS for BioCast and 3DOG.**
3D Optical Volume Generator v1.0 3DOG	**VTR 3QFY14 OPTEST to follow**	**Provides forecasts of the 3D optical environment by fusing gliders, satellites and ocean models in support MIW diver and laser imaging operations.**
EODES v1.0 (AQS-24)	**Delivery 4QFY14**	**Provides performance surfaces to support underwater laser imaging systems (AQS/EODES) for AQS24, airborne laser systems (ALMDS), EO bathy systems, and diver operations (visibility/vulnerability)**

Transition of BioCast for Optical Forecasting (Surface Only) - Version 1.0

BioCast VTR –

- Capability to forecast surface bio-optical properties in support of shallow water Mine Warfare Operations (diver, laser imaging system performance – AQS24, lidar penetration depth and water clarity)
- Delivered to NAVO December 2013 (1QFY14)
- NAVO POC stated "VTR is acceptable and currently in the process of being accepted"
- OPTEST planned to start soon

VTR Highlights:

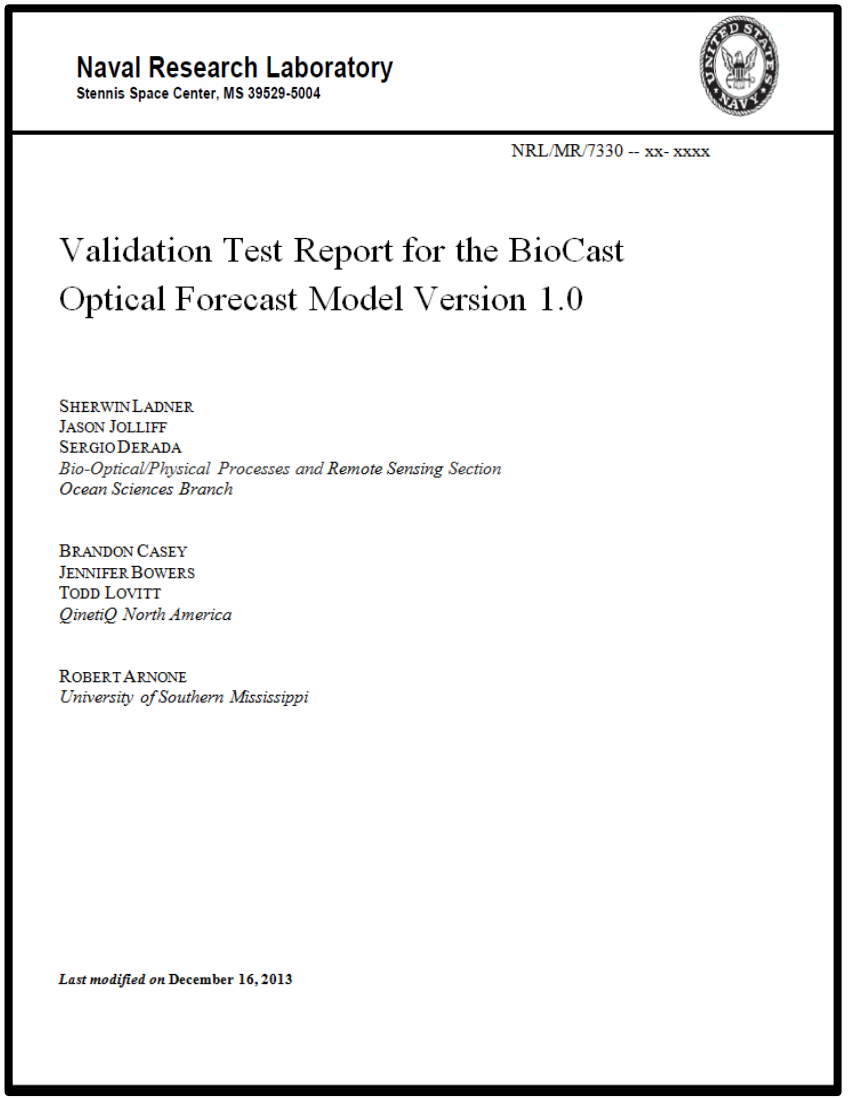
- 27 pages

-Test Case 1: Optical forecast validation in Miss Bight (Dec 2011- Oct 2012) with comparisons to OpCast v2.0 (2D advection)

-Results show BioCast had better error distributions

-Test Cast 2: Optical forecast (24 Hr) validation during Trident Warrior 2013.

- Results show forecast better than persistence.



Naval Research Laboratory
Stennis Space Center, MS 39529-5004

NRL/MR/7330 -- xx- xxxx

Validation Test Report for the BioCast Optical Forecast Model Version 1.0

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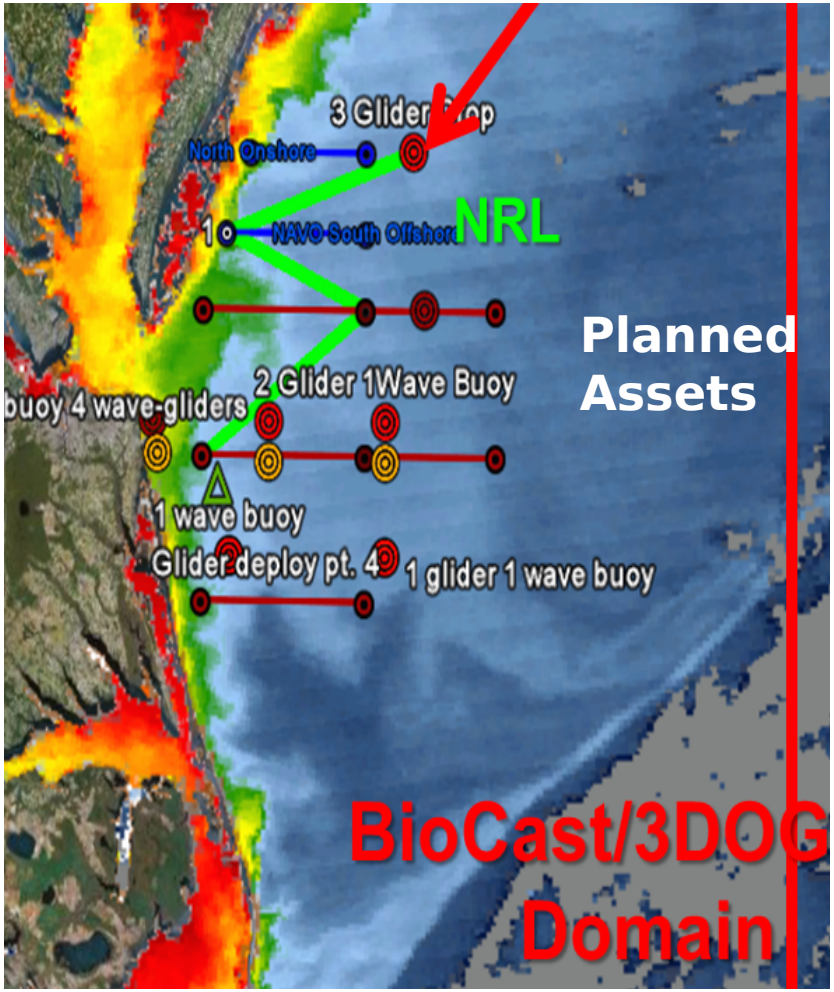
Last modified on **December 16, 2013**

Trident Warrior July 2013
2D/3D Underwater Optics Forecast

U.S. East Coast
Chesapeake Bay Virginia



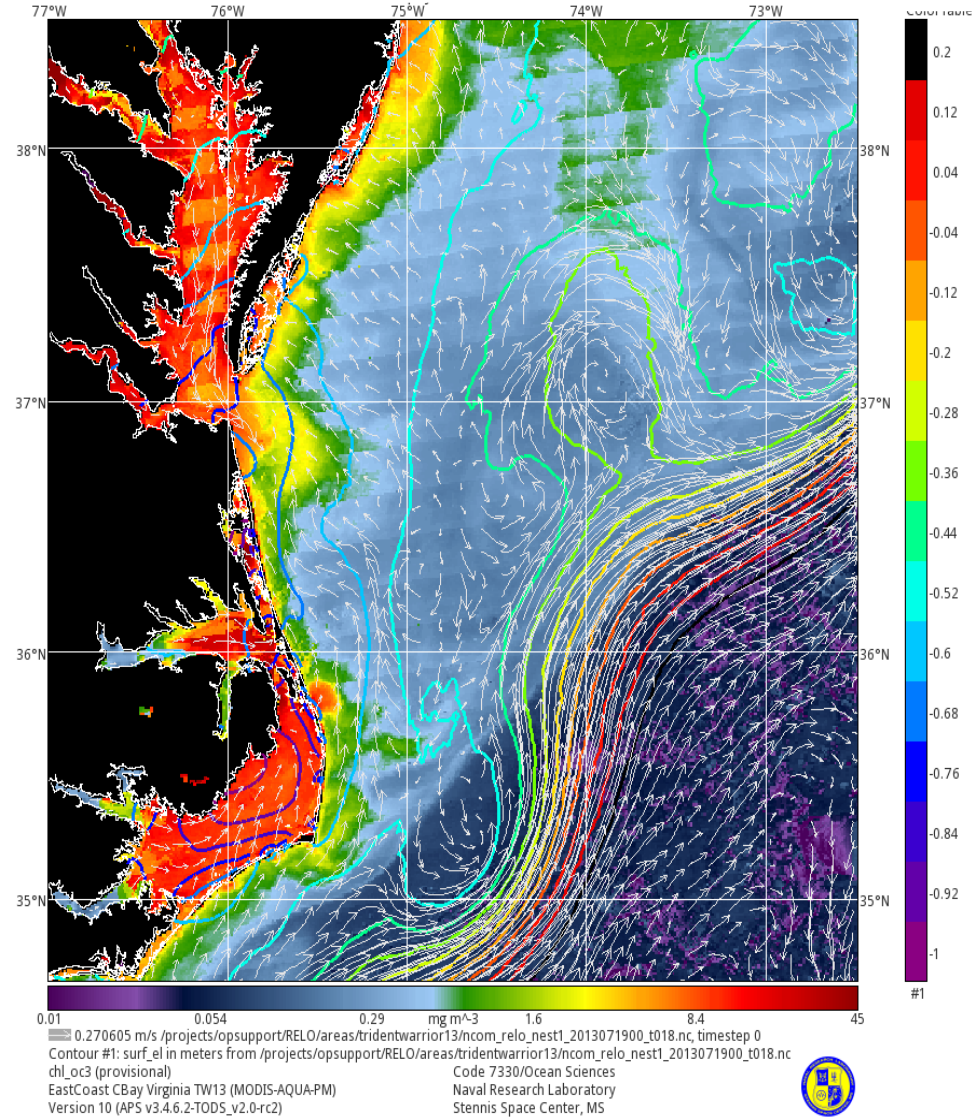
OBJECTIVES:

1. ***Produce 3D optical distributions for the exercise area:***
   - ***Couple surface satellite ocean color imagery with glider data, model results (MLD depth, intensity) – 3D Optical Generator (3DOG).***
   - ***Deploy gliders to tune vertical coefficients in 3D optical model.***
   - ***Evaluate 3DOG software operationally.***
   - ***Validate 3DOG Optical Volumes (VTR).***

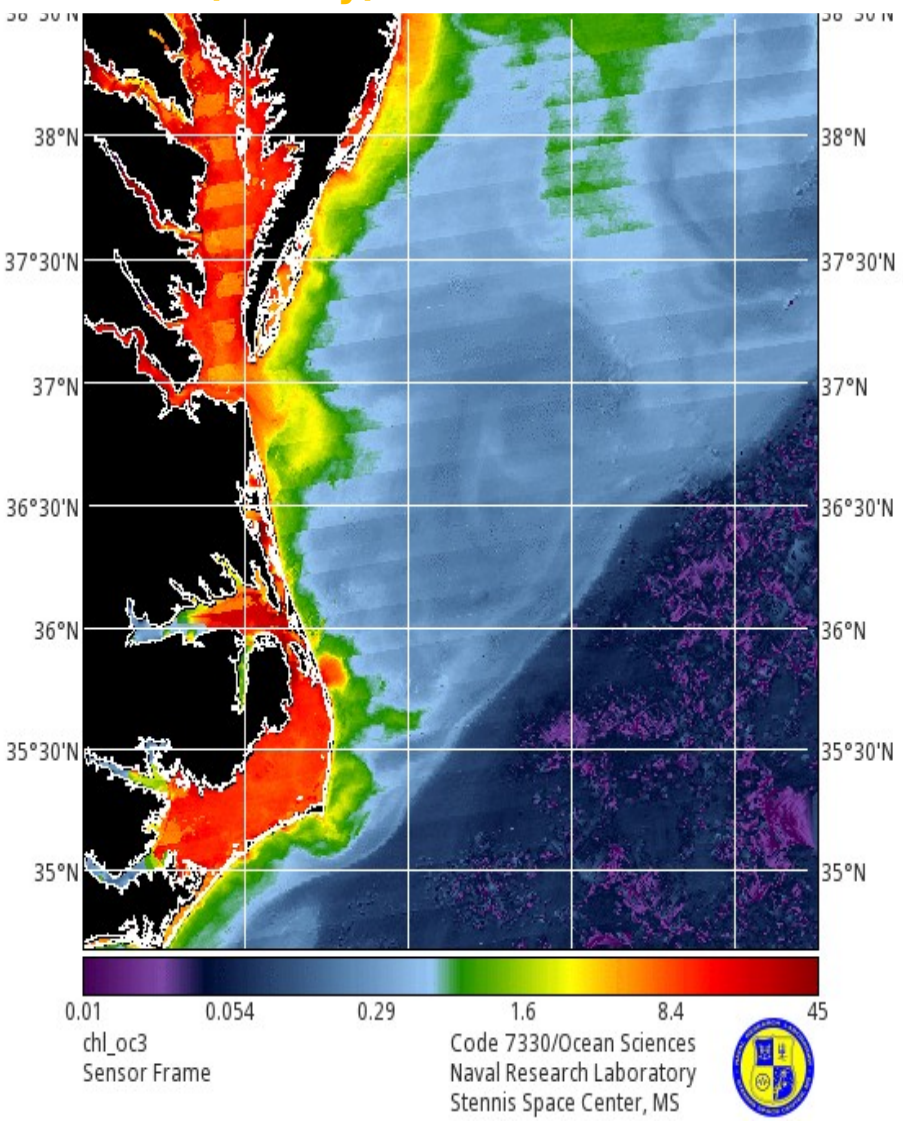
2. ***Forecast short-term surface optical distributions:***
   - ***Run and evaluate BIOCAST operationally (24hr surface forecast vs. persistence)***

Forecasting Surface Bio-Optical Properties
Trident Warrior 13 Merging Satellite Bio-Optical Properties and Modeled Currents - BIOCAST v1.0

19, 2013 MODIS Aqua Chlorophyll Initialization Field w/ Model Currents & SSH Contours



19, 2013 MODIS Aqua Chlorophyll ur (Hourly) Forecast - Animation

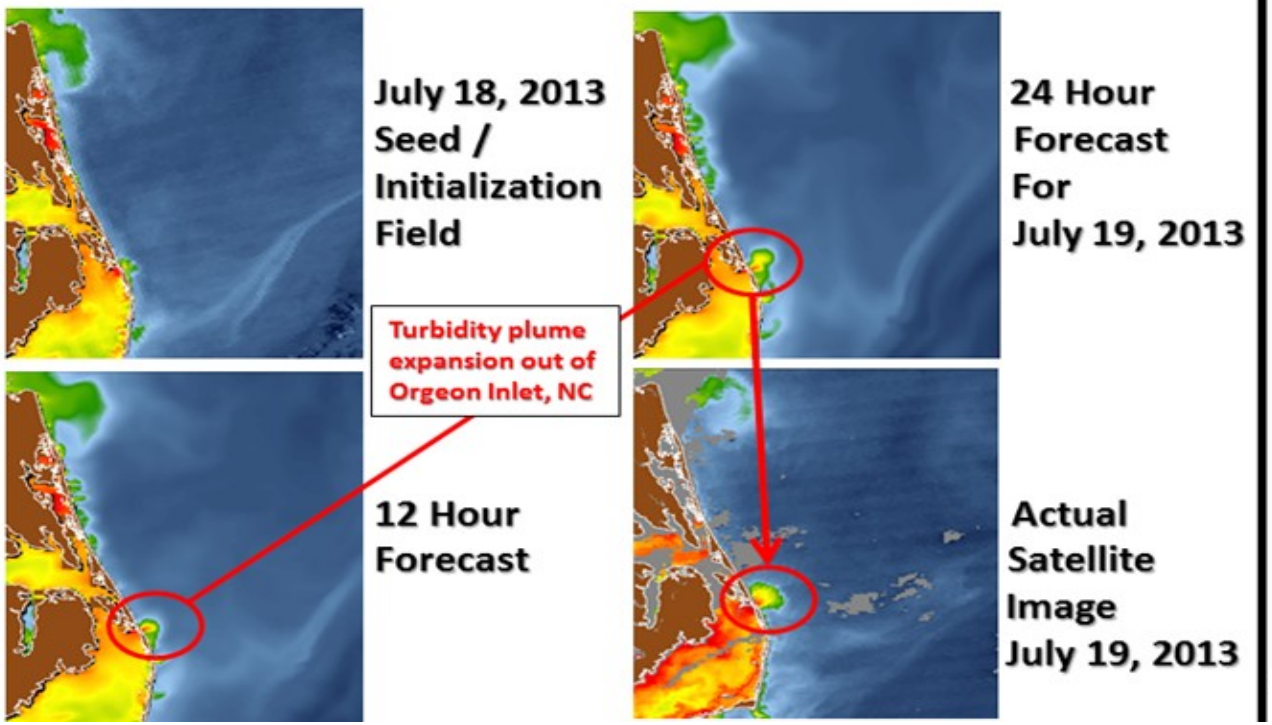


Forecasting Surface Bio-Optical Properties

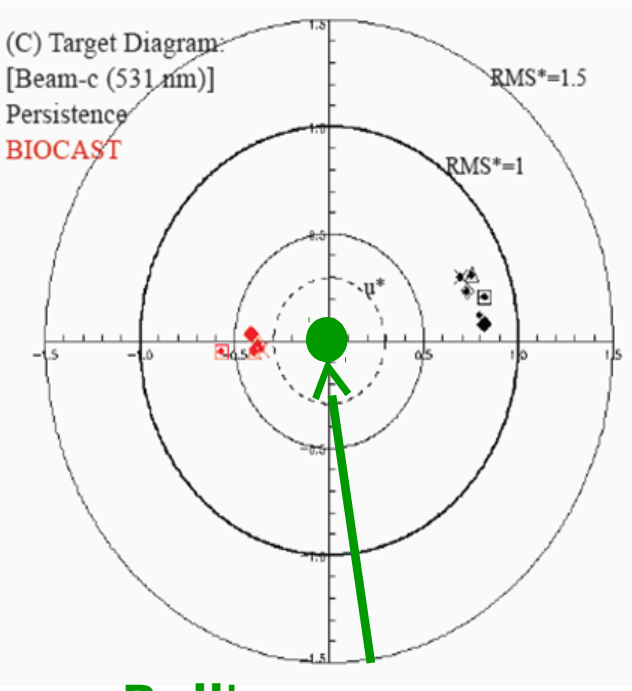
Trident Warrior - Chesapeake Bay, VA – *July 18, 2013*

Seed the Model with Satellite Bio-Optical Products → Advect Satellite Properties forward (hourly steps) Conservative Tracers → Compare with Next Days Satellite Bio-Optical Products

c531nm / Optical Field



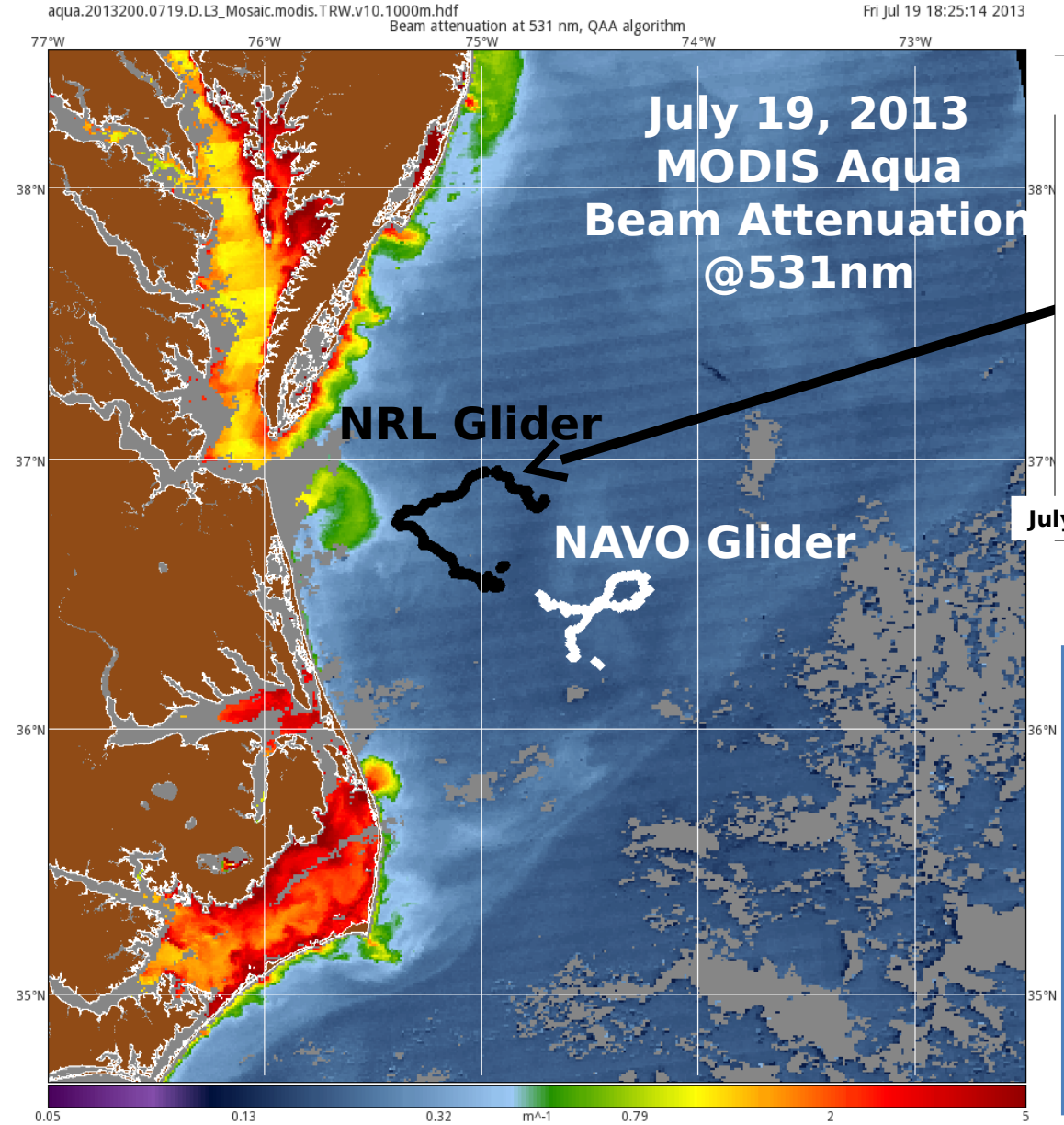
BioCast vs Persistence

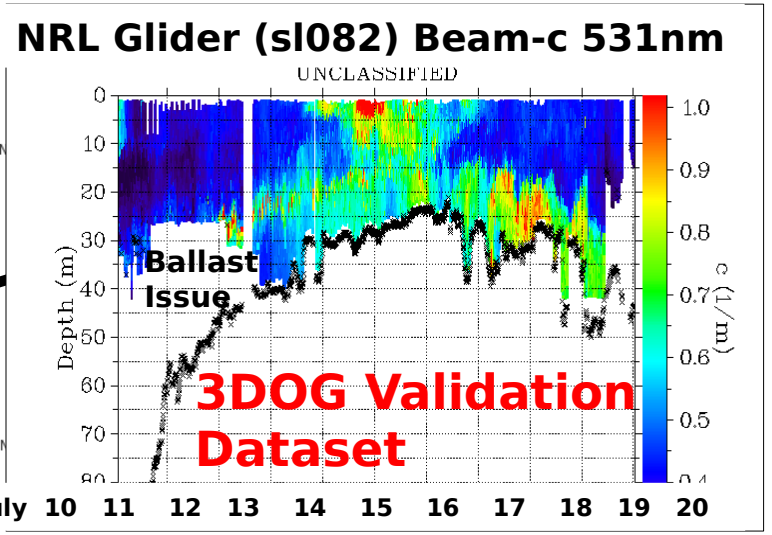


Bull's-eye = no error

Statistical summary diagram compares 30-day latest pixel composites (persistence) against the next-day MODIS satellite product (black) and BIOCAST 24-hour forecast against the same next-day MODIS product (red). Statistics are generated from 60-days of 'next-day' comparisons (1 July – 30 August 2013).

Predicting the 3D Optical Environment by Fusing Satellite, Gliders and Models during Trident Warrior July 2013





- Selected optical profiles (20) were used to generate/tune coefficients for 3D optical model
- Non-selected optical profiles (330) are being used for validation
- NAVO glider omitted from 3DOG evaluation due to issue with elevated optics in deep ocean.

3DOG Glider Optimization – Tuning Coefficients

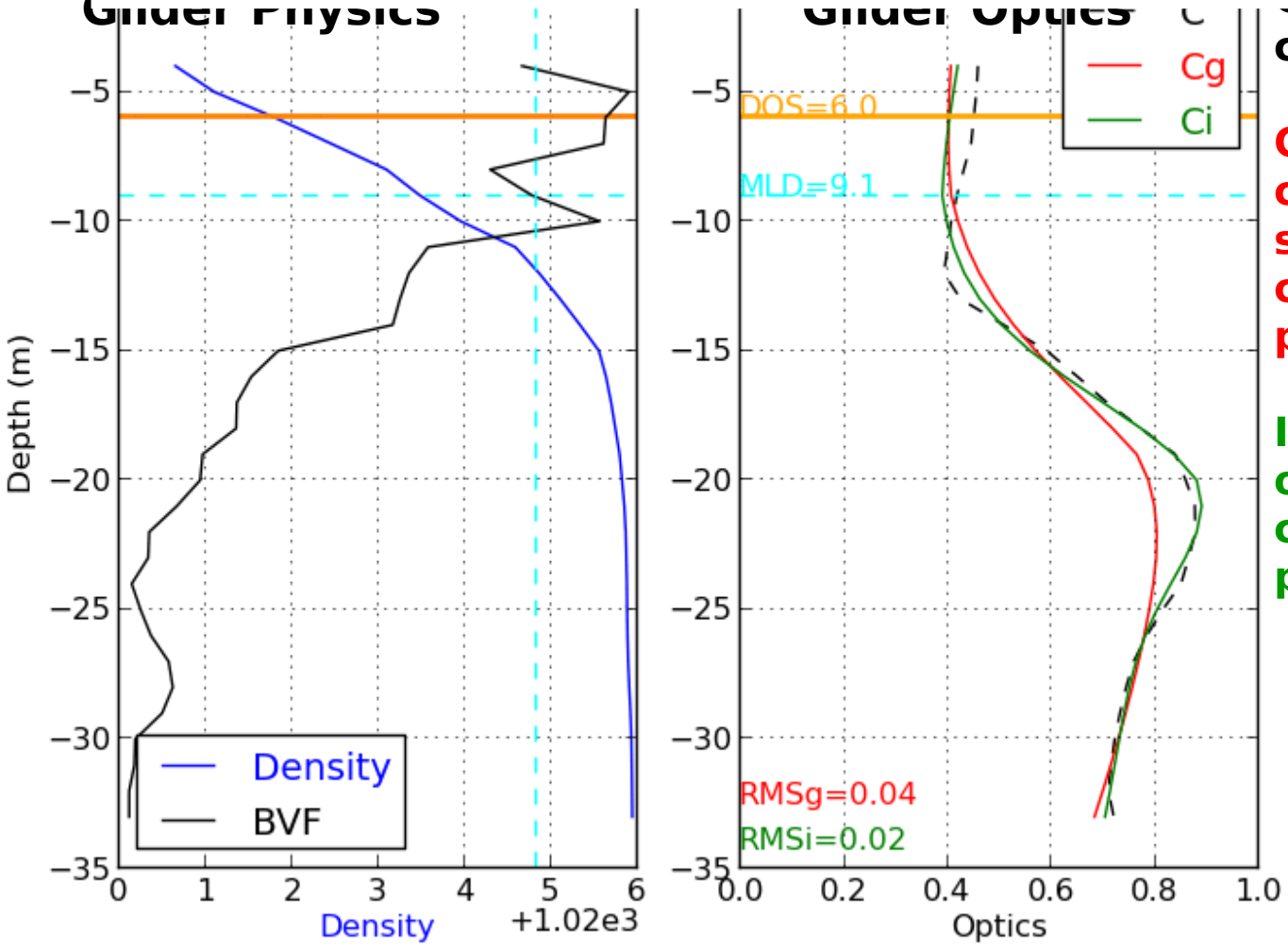
Trident Warrior – July 17, 2013

3DOG Predicted Beam Attenuation 531nm Profiles

Defining Regional Optical/Physical Relationship

Density / MLD Predicted Optics

Observed & Glider Insitu Beam-c



Global optimized coefficients - 20 selected profiles covering 24 hour period

Individually optimized coefficients - each profile

Mean RMS

0.05

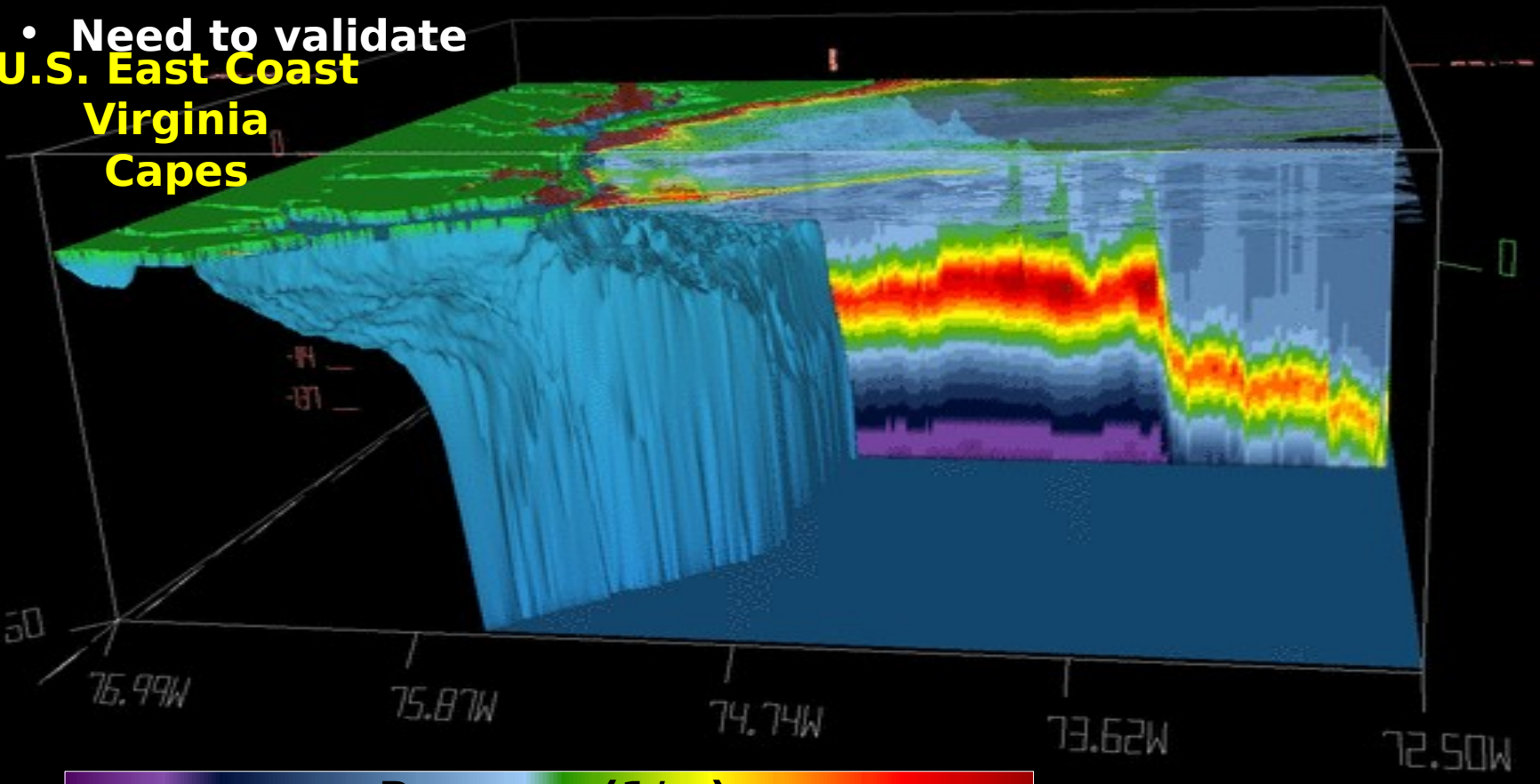
0.02

Trident Warrior 2013 July 17, 2013
3DOG Volume - Beam Attenuation 531nm

Preliminary Results Suggest:

- Coastal/shelf overturning, mixing, resuspension/sedimentation/nephloid layers
- Optical layers migrating up the shelf
- Interactions between surface features and subsurface
- Need to validate

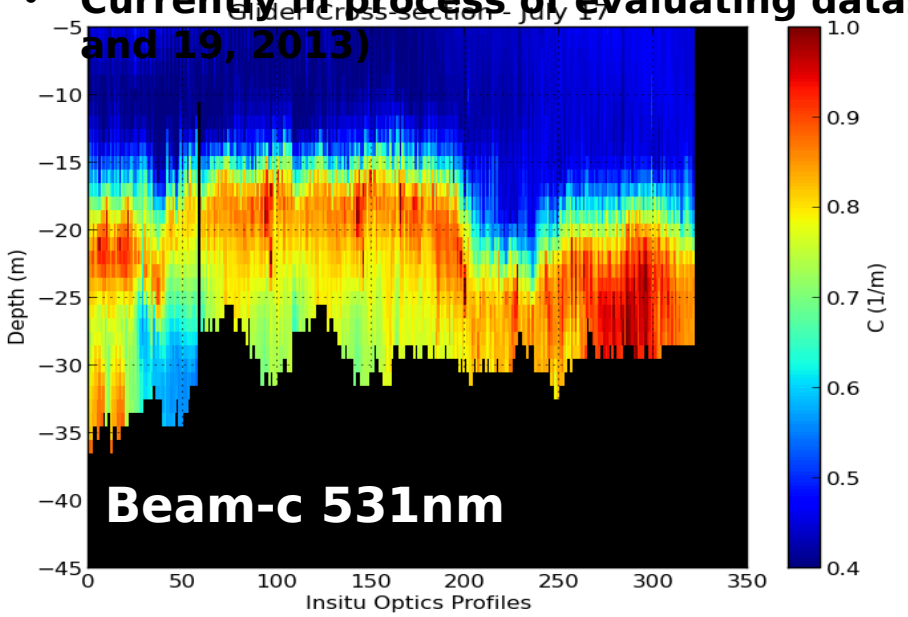
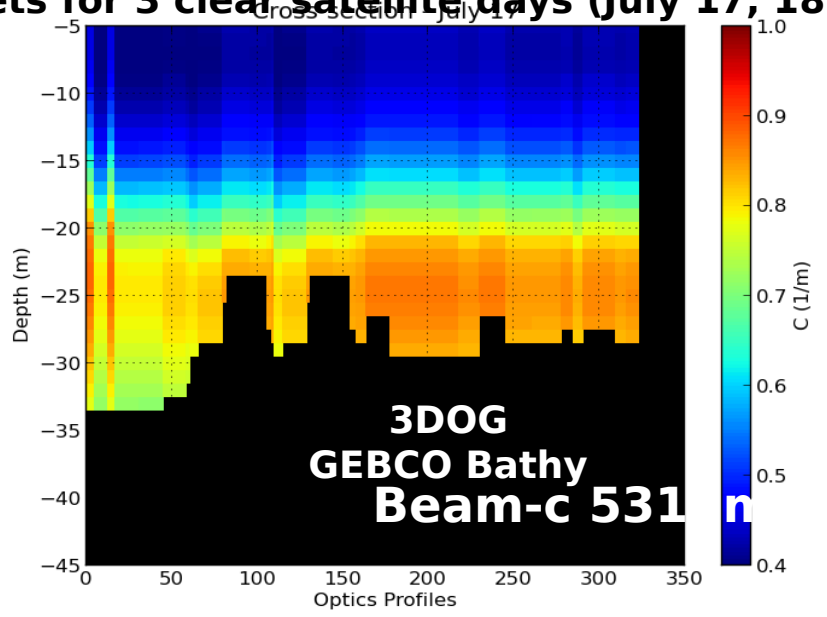
U.S. East Coast
Virginia Capes



Beam-c (1/m)

0.34 0.47 0.64 0.88

Bathymetry generated using Bathygen / GEBCO database

3DOG Validation - Trident Warrior 13 – July 17, 2013
Preliminary Validation Results

- **An optical (beam attenuation 531nm) layer is observed in glider profiles near bottom. Preliminary 3DOG results mimic the same optical layer.**
- **The relationship between the observed and modeled optical fields is dependent on the fidelity of the physical model to the observations.**
- **Differences between observed and predicted possibly due to model bathy (flat bottom) and vertical resolution (5-10m bins > 10m) not capturing fine scale details in observations, MLD selection and bottom turbulence/sediment resuspension.**
- **Observations span 24 hours whereas satellite and model are coincident/static (time of satellite overpass) in 3DOG.**
- **Currently in process of evaluating datasets for 3 clear satellite days (July 17, 18 and 19, 2013)**